Invasive Species Management Update: Glossy Buckthorn (*Frangula alnus*) at Seney National Wildlife Refuge (2006)

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Introduction

A species native to Eurasia, Glossy Buckthorn (*Frangula alnus,* hereafter GLBT) was introduced to North America in the late nineteenth century for horticultural purposes (Voss 1985). GLBT leaves are 0.5 – 2.8 in. long, alternate, simple, ovate and deeply veined. The tops of the leaves are light to dark green, with a slight gloss and a lighter green below; identification of GLBT is easiest in the fall because it retains green foliage longer then native plant species (Heidorn 1990). Flowering occurs from May to June and the inflorescence consists of perfect five-petal, whitish-yellow flowers. Fruit begins to form in drupes in July and last through September (Barnes 1981). Initially the berries are yellow-green, but ripen to red, then to black, as the season progresses.

The bark of GLBT ranges from reddish-green in younger plants to a darker grey-green in more mature plants. When cut, it can be differentiated from other shrubs and trees because of its distinctive yellow wood. The sap wood is a rich yellow color and the heartwood a pinkish-orange when first cut, fading with time (WI-DNR 2004). The entire shrub may grow as tall as 22 ft. with many stems branching from the base. In older shrubs, base stems can be as large as 10 in. in diameter (Heidorn 1990). GLBT's rapid growth and ability to grow densely were characteristics first thought to make it ideal for use as hedgerows and for other landscaping purposes.

GLBT was first documented in Michigan in Delta County in 1934 (Voss 1985). The arrival of GLBT at Seney National Wildlife Refuge most likely occurred in the 1940's or 1950's. It is thought that Refuge staff planted GLBT around the Visitor Center as a shrub (McNeil et. al. 1999), but a review of the historical records at the Refuge does not mention this species. A survey conducted by McNeil et al. (1999) indicated that GLBT was present and widespread in Unit 1 of the Refuge and on adjacent Michigan Department of Natural Resources (MDNR)

lands. Further work has identified scattered areas of Unit 2 (especially A-2 and C-2 dikes) with this species as well (Fig. 1).

Intensive management of GLBT aimed at reducing its extent and abundance at the Refuge began in the summer of 2001. Initial treatments included cutting GLBT and applying a 20% glyphosate mixture to the cut stumps. In the summer of 2002 Refuge staff began spraying glyphosate; during that same year, the scorching of seedlings with a propane torch was also utilized. In 2003, the Refuge and the MDNR began a cooperative effort to manage invasive plants, focusing on GLBT. Through this partnership, the State provides a prison crew and guard and the Refuge provides a licensed pesticide applicator and the glyphosate-based herbicide and associated equipment. The Refuge began another partnership with Michigan Technological University in 2004 to research the efficacy of different GLBT management treatments (Nagel et. al. 2004). Results from this research—and a related manuscript—are expected in the Fall 2006.

The 2006 season's focus was to continue GLBT management efforts in primarily Unit 1 of the Refuge based on occurrence data collected in 2005 (Fig. 1 and 2). Due to environmental, health, and cost concerns associated with herbicide use, we conducted a study to investigate the success of lowering the concentration of glyphosate used for foliage spray application of re-sprouts. We hypothesized that a 2.5% glyphosate concentrated solution would be as effective at killing GLBT re-sprouts as the 5% previously used.

Methods

Herbicide Concentration Study

Study plots of three treatments and a control group were established in a fairly homogeneous study area dominated by GLBT along the North Show Pool west dike. The study area was selected by field scouting and specialist opinion. A study plot consisted of one GLBT stem cluster base with at least three main stems. Each study group had 15 plot replicates for a total of 60 plots. The plots were systematically distributed within the study area and marked by a color-coded rebar (white: control, green: 1.25%, orange: 2.5%, blue: 5%). The plots were spaced at least 1.64 ft. (0.5 m) apart from cluster bases. The number of GLBT stems and general plant characteristics (average stem height and stump or seed sprout) in each plot were recorded during initial observations.

On June 9, 2006, GLBT in the treatment plots were sprayed once with a 1.25, 2.5, or 5 percent concentrated glyphosate solution diluted with tap water and surfactant (0.64 oz.

surfactant/128 oz. solution). The control was sprayed with tap water. The spray date conditions included a temperature range of 60- 64^{o}F, <1 mph wind, 50-75% cloud cover, and 57% relative humidity. The study plots were monitored once a week for the duration of the 2006 field season. The number of GLBT dead stems and change in general plant characteristics (i.e., browning or shriveling leaves) was recorded during each monitoring period. Stems were classified as dead if they had at least 75% of leaves shriveled, brown or fallen. The percent stem death was calculated as a measurement of treatment success. A treatment was determined a success if more than 50% of stems were dead.

Management

The Refuge's 2006 GLBT management season began on May 31, 2006 and ended on September 6, 2006. General management treatments were similar to previous years (i.e., 20% sponge stump and 5% foliage spray application of glyphosate). Detailed instructions on the Accord label were followed regarding preparation and application of the glyphosate. Spraying devices included a hand pump and power applicator. In June 2006, we decreased the foliage spray mixture from 5% to 2.5% after research plots supported the use/success of a lower concentration application. When spraying occurred in pedestrian concentrated areas, signs were placed at appropriate increments and left for at least 24 hours to warn the public that herbicide had been applied to an area.

During the third week in June, work with the prison crew began. The prisoners used chain saws and heavy duty weed whackers to cut any GLBT plants measuring >3 cm in diameter or >2 m in height (Fig. 2). Once the stumps were cut, a 20% glyphosate solution was applied to each stump. The primary treatment area was concentrated along the Refuge's northeast border with M-77 (i.e., around the Show Pools). GLBT re-sprouts were sprayed in areas between the Refuge ditch and M-77 stretching from North Entrance Road to the northeast Refuge boundary, the dike surrounding the entire South Show Pool, as well as the North Show Pool east and west dikes. We paddled both Show Pools and Holland Creek in order to treat plants that were extending off the bank by spraying over the boat to avoid water contamination. GPS readings collected during the 2005 season were used to determine initial areas for treatment of re-sprouts. Aerial photographs from 2005 were used to identify potential sites of GLBT based on waterway and forest stand locations. In last August and September, the prison crew primarily worked on MDNR lands.

Results

Herbicide Concentration Study

Most plots consisted of plants between 3 – 7 ft. in height prior to treatments (Table 1). Of the 60 plots, only three were determined to be seed sprouts; the remaining plots were dominated by re-sprouts from previously treated stumps. The mean stem number was 17 (+/-1 SD) stems per plot. Over half of the 2.5% and 5% plots had dead stems one week after treatment. Most 1.25% plots exhibited some indication of treatment, such as wilted, orange leaves, but could not be considered dead stems. No dead stems were observed within the control plots. All treated plots had brown leaves or no leaves at all by the fourth week. All treatment plots observed a 100% stem death by July 5, 2006.

Management

A total of 43 days were spent managing GLBT during the 2006 field season (Table 2). A total area of over 500 new acres was surveyed/explored with plants present in the majority of locations (Fig. 2). Sizable areas with large shrubs were present on major islands in both Show Pools and pine stands north of the pools (Fig. 2). A total of seven Global Positioning System (GPS) points were recorded for notable size stands and single, isolated plants at extreme locations (Table 3). The largest stump treated measured 6 in. in diameter. The oldest stump treated was estimated at being over 45 years old.

A daily average of four field hours was devoted to controlling GLBT. The majority of field work was done in the morning hours with generally favorable weather conditions being at an average of 70^{o}F, <5 mph wind and <25% cloud cover. A total of 3,416 oz (26.68 gal.) of the 5% mixture was sprayed over the first month of the season. A total of 17,782 oz (138.92 gal.) of the 2.5% mixture was sprayed during the second half of the season. Twenty-four days were spent working with the prison crew on large shrub management. The average prison crew size was 6 men, with 3 saws operating. A total of 315 oz (2.46 gal.) of the 20% solution was applied to cut stumps. See Table 2 for a 2006 herbicide report summary.

Discussion

Preliminary study results support the application of a decreased concentration of 2.5% glyphosate solution on GLBT re-sprouts. A GLBT literature review generated a suggested range of concentrations of glyphosate between 1.5 and 10% (WI-DNR 2004). The most significant variable to consider when interpreting the study results into management practice is the difficulty

in consistent dosage of solution applied by applicators due to the varying scale of treatment areas and environmental conditions. Although possibly conservative, our recommendation is to implement the 2.5% glyphosate dosage for the foliage spray treatment of GLBT re-sprouts and seedlings (< 2 in.) in future management efforts. We also suggest the study site be revisited in the next growing season to observe the re-generation of the treatment plots.

A major achievement of this year's management season was the discovery and treatment of new areas of large GLBT shrubs. Areas "stump treated" in 2005 had abundant re-sprouts, which reinforced the need for multiple year revisits. In addition to stump re-sprouts, we observed numerous sprouts growing through cut plant piles from 2005. We also observed a GLBT small-scale distribution trend of large plant clusters along the edges of waterways and pine stands. This general pattern was extremely useful in determining areas to concentrate efforts, with the assistance of aerial photography. Canoeing efforts yielded treatment of several established shrubs on the major island systems in both Show Pools, as well as the sporadic small/young pioneer plants on the surrounding small islands (~ 20 ft. mean diameter). The examination of an established shrub on the large North Show Pool Island derived an estimated age over 45 years old, which confirms possible introduction dates as early as the 1950s.

Recommendations for the 2007 management season include revisiting all 2006 treatment areas (Fig. 1 and 2) with a 2.5% foliage spray, using the prison crew to scout habitat based on aerial photography, treating all islands with GLBT in Unit 1 (especially E-1, F-1, H-1, Upper F, and Visitor Center), and treating the interior pool edges of these same pools. Daily treatment times should be considered in future management planning due to the area's weather patterns. The time of day to treat most effectively is thought to be mid day (1000-1400h) after the morning dew has transpired and before the afternoon wind gains speed. Care should be given to avoid contact with any native plants in the vicinity.

Literature Cited

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Table 1: Data summary of the glyphosate herbicide concentration - glossy buckthorn treatment study at Seney NWR (2006).
(Plots C1: control, T1: 1%, T2: 2.5%, T3: 5%) (Height: L (low) <1m, M (medium) 1-2m, H (high) >2m)

Date	6/9/2006	6/13/2006		6/19/2006	6/26/2006	7/5/2006	7/13/2006
Temperature	60°F	65°F	DP 44°F	70°F	68°F	63°F	60°F
Wind	5-15 mph	0.8 mph	RH 57%	5-10mph	<5mph	5-10mph	5-10mph
Cloud Cover	<25%	50-75%	BAR 994.8	<25%	<25%	<25%	<25%
Plot	Initial	Average	Type of	Percent of Dead Stems (%)			
Number	Stem #	Height	Sprout	Week 1	Week 2	Week 3	Week 4
C1 P1	31	H	Stump	0.0	0.0	0.0	0.0
T1 P1	16	L	Stump	37.5	100.0	100.0	100.0
T2 P1	14	L	Stump	42.9	100.0	100.0	100.0
T3 P1	33	H	Stump	39.4	100.0	100.0	100.0
C1 P2	16	M	Stump	0.0	0.0	0.0	0.0
T1 P2	24	H	Stump	0.0	100.0	100.0	100.0
T2 P2	7	H	Stump	0.0	100.0	100.0	100.0
T3 P2	8	H	Stump	25.0	100.0	100.0	100.0
C1 P3	31	H	Stump	0.0	0.0	0.0	0.0
T1 P3	14	H	Stump	14.3	100.0	100.0	100.0
T2 P3	24	H	Stump	79.2	100.0	100.0	100.0
T3 P3	8	H	Stump	50.0	100.0	100.0	100.0
C1 P4	7	H	Stump	0.0	0.0	0.0	0.0
T1 P4	43	L	Stump	0.0	74.4	100.0	100.0
T2 P4	26	H	Stump	3.8	96.2	100.0	100.0
T3 P4	39	L	Stump	35.9	100.0	100.0	100.0
C1 P5	10	M	Stump	0.0	0.0	0.0	0.0
T1 P5	15	L	Stump	20.0	100.0	100.0	100.0
T2 P5	22	L	Stump	31.8	100.0	100.0	100.0
T3 P5	9	H	Stump	44.4	100.0	100.0	100.0
C1 T6	15	L	Stump	0.0	0.0	0.0	0.0
T1 T6	57	L	Stump	24.6	98.2	100.0	100.0
T2 T6	6	H	Seed	0.0	100.0	100.0	100.0
T3 T6	29	L	Stump	62.1	100.0	100.0	100.0
C1 P7	18	H	Stump	0.0	0.0	0.0	0.0
T1 P7	37	M	Stump	2.7	27.0	100.0	100.0
T2 P7	15	M	Stump	20.0	100.0	100.0	100.0
T3 P7	15	M	Stump	0.0	100.0	100.0	100.0
C1 P8	11	H	Stump	0.0	0.0	0.0	0.0
T1 P8	18	M	Stump	5.6	100.0	100.0	100.0
T2 P8	6	H	Stump	50.0	100.0	100.0	100.0
T3 P8	22	L	Stump	40.9	100.0	100.0	100.0
C1 P9	9	M	Seed	0.0	0.0	0.0	0.0
T1 P9	14	H	Stump	0.0	92.9	100.0	100.0
T2 P9	21	M	Stump	33.3	100.0	100.0	100.0
T3 P9	8	H	Stump	62.5	100.0	100.0	100.0
C1 P10	17	M	Stump	0.0	0.0	0.0	0.0
T1 P10	11	H	Stump	0.0	100.0	100.0	100.0
T2 P10	15	H	Stump	46.7	100.0	100.0	100.0
T3 P10	16	H	Stump	18.8	100.0	100.0	100.0
C1 P11	16	M	Stump	0.0	0.0	0.0	0.0
T1 P11	11	M	Stump	18.2	100.0	100.0	100.0
T2 P11	16	L	Stump	12.5	100.0	100.0	100.0
T3 P11	10	L	Seed	40.0	100.0	100.0	100.0
C1 P12	16	H	Stump	0.0	0.0	0.0	0.0
T1 P12	8	M	Stump	12.5	100.0	100.0	100.0
T2 P12	44	L	Stump	4.5	100.0	100.0	100.0
T3 P12	28	M	Stump	42.9	100.0	100.0	100.0

C1 P13	13	H	Stump	0.0	0.0	0.0	0.0
T1 P13	12	M	Stump	0.0	91.7	100.0	100.0
T2 P13	11	M	Stump	81.8	100.0	100.0	100.0
T3 P13	15	M	Stump	20.0	100.0	100.0	100.0
C1 P14	7	H	Stump	0.0	0.0	0.0	0.0
T1 P14	11	H	Stump	0.0	100.0	100.0	100.0
T2 P14	7	H	Stump	14.3	100.0	100.0	100.0
T3 P14	11	H	Stump	9.1	100.0	100.0	100.0
C1 P15	4	M	Stump	0.0	0.0	0.0	0.0
T1 P15	9	M	Stump	0.0	100.0	100.0	100.0
T2 P15	9	H	Stump	11.1	100.0	100.0	100.0
T3 P15	11	H	Stump	36.4	100.0	100.0	100.0

Table 2. Summary of glyphosate use during the 2006 field season at Seney National Wildlife Refuge.

Date	Amount (oz.)	Concentration (%)	Daily Total Amount (oz.)	Location	Prison Crew
5/31/2006	40	5	40	T45NR13WS9W1/2	0
6/1/2006	1024	5	1024	T45NR13WS16E1/2, T45NR13WS21E1/2	0
6/5/2006	896	5	896		0
6/8/2006	1024	5	1024	T45NR13WS16SE1/4NW1/4	0
6/12/2006	896	5	896		0
6/15/2006	12	5	12	T45NR13WS21NW1/8	0
6/19/2006	0	5	0	T45WR13WS16	4
6/20/2006	384	5	384	T45NR13WS21NE1/4NW1/4	4
6/21/2006	36	5	36	T45NR13WS16NW1/4NE1/4	11
6/22/2006	24	20		T45NR13WS16NW1/4SE1/4	
6/22/2006	28	5	52	T45NR13WS21NE1/4NW1/4	7
6/23/2006	12	20	12	T45NR13WS16NW1/4NE1/4	11
6/26/2006	18	20	18	T45NR13WS16NW1/4SE1/4	12
6/27/2006	20	20	20	T45NR13WS16NW1/4SE1/4	12
6/28/2006	14	20	14	T45NR13WS16NW1/4SE1/4	7
7/5/2006	320	2.5	320	T45NR13WS16SE1/4NW1/4	6
7/7/2006	12	20		T45NR13WS16SE1/4NW1/4	6
7/7/2006	288	2.5	300	T45NR13WS16SE1/4NW1/4	
7/10/2006	12	20		T45NR13WS16SE1/4NW1/4	9
7/10/2006	448	2.5	460	T45NR13WS16SE1/4NW1/4	
7/11/2006	64	2.5	64	T45NR13WS16N1/2	0
7/13/2006	64	2.5	64	T45NR13WS16SE1/4NW1/4	0
7/17/2006	256	2.5		T45NR13WS16SE1/4NW1/4	5
7/17/2006	8	20	264	T45NR13WS16SE1/4NW1/4	
7/18/2006	16	20	16	T45NR13WS16SE1/4NW1/4	5
7/19/2006	384	2.5		T45NR13WS16SE1/4NW1/4	
7/19/2006	14	20	398	T45NR13WS16SE1/4NW1/4	6
7/21/2006	18	2.5	18	T45NR13WS21SE1/4NW1/4	0
7/25/2006	12	20		T45NR13WS16SW1/4NE1/4	4
7/25/2006	640	2.5	652	T45NR13WS16SW1/4NE1/4	
7/31/2006	256	2.5	256	T45NR13WS16SE1/4NW1/4	0
8/1/2006	768	2.5	768	T45NR13WS21NE1/8, T45NR13WS16SE1/4SW1/4	0
8/8/2006	704	2.5	704	T45NR13WS16SE1/4SW1/4	8
8/9/2006	1408	2.5	1408	T45NR13WS16SE1/4W1/2, T45NR13WS21NE1/8	8
8/15/2006	256	2.5	256	T45NR13WS16,21	
8/16/2006	192	2.5	193	T45NR13WS26,27,28	
8/16/2006	256	2.5	256	T45NR13WS16,21	
8/17/2006	192	2.5	192	T45NR13WS21,28	
8/17/2006	128	2.5	128	T45NR13WS20	
8/18/2006	1664	2.5	1664	T45NR13WS21	
8/21/2006	2688	2.5	2688	T45NR13WS20	
8/22/2006	1920	2.5	1920	T45NR13WS20,21	

8/22/2006	12	20	12	T45NR13WS16	7
8/23/2006	888	2.5	888	T45NR14WS22	
8/23/2006	16	20	16	T45NR13WS22	7
8/24/2006	16	20	16	T45NR13WS22	7
8/24/2006	1408	2.5	1408	T45NR13WS9,16	
8/28/2006	8	20	8	T45NR13WS22	6
8/29/2006	12	20	12	T45NR13WS22	8
8/29/2006	940	2.5	940	T45NR13WS20,21	
8/30/2006	12	20	12	T45NR13WS22	7
8/30/2006	384	2.5	384	T45NR13WS16	
8/31/2006	26	20	26	T45NR13WS22	8
8/31/2006	256	2.5	256	T45NR13WS14	
9/1/2006	16	20	16	T45NR13WS22	8
9/1/2006	14	20	14	T45NR13WS21	
9/1/2006	32	2.5	32	T45NR13WS21	
9/5/2006	21	20	21	T45NR13WS22	8
9/5/2006	1536	2.5	1536	T45NR13WS20	
9/6/2006	2304	2.5	2304	T45NR13WS21	

Table 3: Summary of Global Position System (GPS) reference points (Datum: NAD83) for noteworthy locations of single plants and large clusters of GLBT on Seney National Wildlife Refuge.

Coordinates	Description
N 46.307° W -86.02164°	Pine Creek Road (single plant)
N 46.2919° W -85.9378°	North show pool main island (multiple large plants)
N 46.2914° W -85.9413°	N. show pool W. dike north end/boundary (multiple large plants & re-sprouts)
N 46.2914° W -85.9381°	N. show pool W. dike crossing to "v" peninsula (multiple large plants)
N 46.2888° W -85.9466°	M-77 northeast boundary most north observed (single plant)
	M-77 trailhead bridge GLBT forest north boundary (multiple large plants)
	M-77 western boundary of pine stand GLBT forest (multiple large plants)

Figure 1. Polygon (red) associated with the area in which invasive plant species were treated with mechanical and chemical means in 2006.

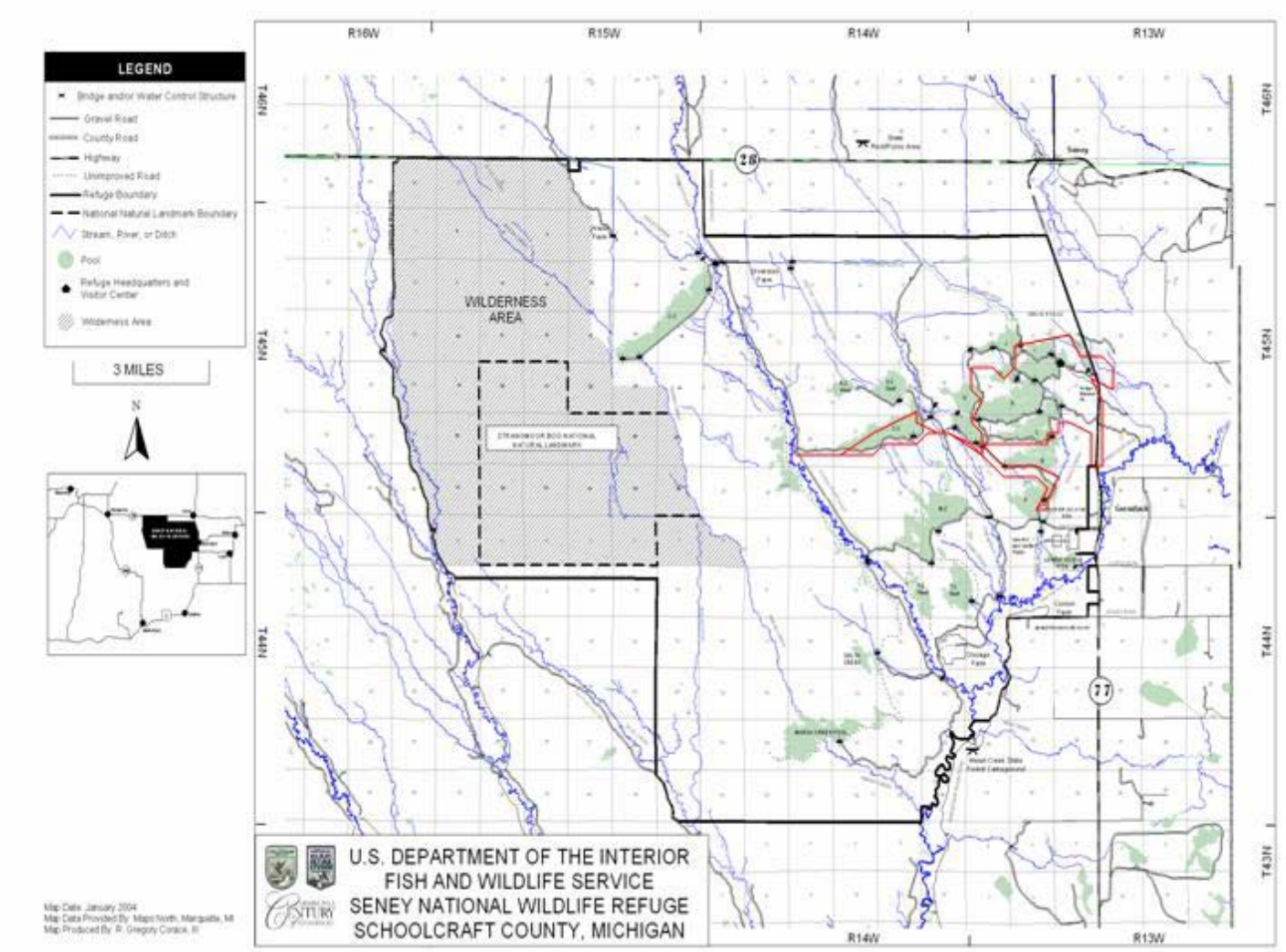

Figure 2. Area in which prison crew worked on Glossy Buckthorn management in 2006.